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ABSTRACT

The effects of analogical and schematic illustrations on the comprehension and retention of expository prose were compared. The population was 191 eighth-grade students at Mahomet Junior High School, Illinois; 134 students' scores were used. Subjects were assigned to two groups through the random distribution of treatment booklets that included a learning task composed of expository prose and either schematic or analogical illustrations regarding the topic of logic gates. Data were collected through four methods: an interest questionnaire administered prior to the learning task; sentiment measure administered immediately following; Test I, which measured initial learning immediately after the task and retention 14 days later; and an interview guide. Pearson product moment correlation coefficients and analyses of covariance were computed. Statistically significant differences were found in subjects' mean scores on object attribute test items during both administrations of Test I. According to mean scores, those students who received the schematic illustrations performed better (81.2 percent) on the object attribute test items than their counterpart students (68.9 percent) who received the analogous illustrations. Students who received the schematic illustrations performed significantly better 2 weeks later when tested for retention (60.6 to 45.1 percent). Findings supported existing theory on analogies and illustrations. (YLB)

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EFFECTS OF ANALOGICAL VS. SCHEMATIC ILLUSTRATIONS ON INITIAL LEARNING AND RETENTION OF TECHNICAL MATERIAL BY EIGHTH-GRADE STUDENTS

BY

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Research Paper Presented at the TED/NAITTE Research Session at the 1991 American Vocational Association Convention in Los Angeles, California

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ORIENTATION TO THE PROBLEM

Throughout history technologists have used illustrations to communicate their thoughts to others. Manuals of technical processes were developed as early as the fifteenth century (Ferguson, 1977). Of equal significance was the inclusion of drawings of machines in engineer's notebooks. The practices of printing manuals and the sharing of notebooks allowed early technologist to convey their ideas to others through drawings thus allowing others to build things from the blueprints in their minds.

These traditions promoted the sharing of information. Thus, it could be said that from before the time Leonardo da Vinci was filling his notebooks with technical drawings, illustrations were being used for educational purposes. Today, pictures, line drawings, schematics, and blueprints are a few examples of the types of illustrations commonly used in the study of technology.

Although illustrations are well established in the teaching of technology, technology continues to evolve. Advancements such as the miniaturization of parts have changed the types of illustrations that are needed. For example, before the introduction of electronics, a picture of a mechanism's parts provided much of the information needed to understand how it worked. In contrast, a picture of a transistor does not provide enough information for someone to understand how it functions. When the nature of an object is such that literal illustrations are not possible or do not help clarify function, we are forced to deal with the topic on a more conceptual

level. This raises the following question. When teaching complex or abstract technological materials, are some types of illustrations better suited for conveying meaning than others?

While the answer to this important question has implications for instruction, recent research provides little evidence to support the use of illustrations in learning text. Research on the use of illustrations is inconclusive (Duchastel, 1980) and is due partially to the diversity of studies (Hurt, 1985; Levie, 1987). Research on illustrations also tends to examine pictures without consideration for the attributes which compose them (Hurt, 1985). Therefore, further research must focus on specific types of illustrations, their attributes, and how well those attributes meet the instructional function of the illustration.

The focus of this study centered on two types of illustrations, analogical and schematics. Analogical illustrations are visual representations that make reference to information that is not literally identified by, but conceptually represented by the visual representation (Hurt, 1985). For example, if a picture of pump was used in place of the heart in a diagram of the human body, the pump would be considered an analogous illustration. The pump represents the heart conceptually. It represents the function the heart performs in the larger biological system but does not imply that they have similar physical attributes.

Schematics are classified in a more general class of illustrations known as diagrams. Schematics consist of line symbols that do not

look like the things they represent, but depict them either logically or conceptually. While schematics have uses in various fields, they are used extensively in electronics.

This study hypothesized that analogical and schematic illustrations differ in their effectiveness depending upon the type of knowledge that is being represented in the lesson. A schematic may be more effective to teach physical attributes (object attributes) while analogical illustrations may provide more information about relationships between those attributes (relational predicates).

STATEMENT OF THE PROBLEM

Because of the pervasiveness of illustrations in the teaching of technical material, instructors need to be knowledgeable of the types of illustrations that are best suited for specific instructional purposes. Thus far, research on the use of illustrations is inconclusive (Duchastel, 1980) which is due partially to the diversity of studies (Hurt, 1985; Levie, 1987). Although some researchers have tried to draw conclusions about illustrations, broad generalizations about them are not possible. Therefore, further research must focus on specific types of illustrations and how well their attributes meet the instructional function of the illustration. More specific to this study, there is a lack of empirical evidence that supports the use of analogical and schematic illustrations to supplement expository prose.

PURPOSE AND RESEARCH QUESTIONS

The purpose of this study was to compare the effectiveness of analogical and schematic illustrations on the comprehension and retention of expository prose. This study was designed to address the following research questions:

1. Is there any difference in the effectiveness of using schematic and analogical illustrations with expository prose to initially learn and retain knowledge of object attributes?

2. Is there any difference in the effectiveness of using schematic and analogical illustrations with expository prose to initially learn and retain knowledge of relational predicates?

3. Are student feelings toward learning affected differently by the use of schematic and analogical illustrations to supplement expository prose?

POPULATION AND SAMPLE

The population for this experiment was 191 eighth-grade students at Mahomet Junior High School located in Mahomet, Illinois. It is a relatively small community with a population of approximately 10,500 people. The school district services many rural subdivisions which are not currently incorporated in the city of Mahomet. The combination of the rapidly growing subdivisions and the rural setting lead to a diverse population of students.

Of the 191 students in the eighth-grade class, 152 students' scores were used in this study. Students were not used for the following reasons. Because the performance tasks required reading,

students identified through achievement tests as reading below the sixth-grade level were excluded. Twenty-one students had standardized reading scores indicating they read below the sixth-grade level and thus were not included in the study. Nine students were absent on the day of the experiment. One student was randomly eliminated to provide an equal number of students in each experimental group. The remaining eight nonparticipants indicated either they or their parents did not want them to take part in the study.

Of the 191 students in the eighth grade class, 134 students' scores were used in the analysis of the retention scores. The original 38 students whose scores were not used for analysis of initial learning were again excluded. Following the initial session, 10 subjects, five from each group were randomly selected for interviews. Their retention scores were not included when analyzing the data to ensure the interview did not skew the results. In addition, five subjects were absent on the day of the retention test. Four subject's scores were randomly eliminated to provide an equal number of subjects in each experimental group.

Once the subjects were selected, they were randomly assigned to two groups. This occurred through the random distribution of treatment booklets. An attempt was made to distribute an equal number of the different booklets in each class. This was to control for any differences between classes and to ensure that the treatments were randomly assigned to subjects.

EXPERIMENTAL DESIGN

The primary design of the main study is represented symbolically as follows:

R	O_1	X_a	O_2	O_3	O_3
R	O_1	X_b	O_2	O_3	O_3

The design has the following characteristics. The "R" represents the procedure of randomly assigning subjects to treatment groups. The $X_\bullet$ represents an exposure or treatment. This experiment had two possible treatment combinations referred to as the learning task. Subjects either received the passage which included expository prose regarding logic gates ($X_\bullet$) supplemented with the analogical illustrations (X_a) or supplemented with schematic symbol illustrations (X_b).

Data was collected at different times throughout the experiment. The interest questionnaire (O_1) was given prior to the learning task. The sentiment measure (O_2) was administered immediately following the learning task. Test I (O_3) was administered once immediately following the sentiment measure and again 14 days after the initial session.

DEVELOPMENT OF THE LEARNING TASK

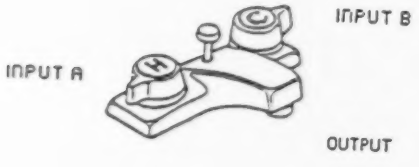
The treatment booklets developed for the main experiment included a learning task that was composed of expository prose and illustrations regarding the topic of logic gates. The passage was written at a seventh-grade level and, including illustrations, was

under five pages in length. After the passage was developed, it was analyzed using the computer program *Sensible Grammar* to determine reading level. *Sensible Grammar* analyzes reading level using the "Flesch" method. A panel of experts, including professionals with seventh- or eighth-grade teaching experience and content specialists, also verified that the content was correct, that the reading level was appropriate for the population and provided suggestions for improving the material.

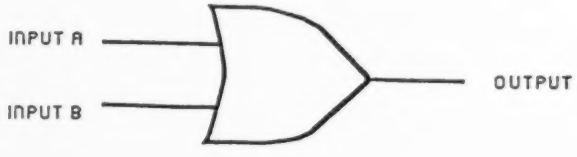
Schematic and analogical illustrations were used with the passage during the learning task. The combination of the type of illustration and passage each student received depended upon the treatment booklet they were randomly assigned. Both types of illustration depicted components regarding logic gates.. References made to the illustrations in the passages were generic in nature. For example, in the logic gate passage, the inputs were referred to as input a and b. As seen in illustration 1, both illustrations were labeled with inputs a and b to prevent unique referrals in the text to particular illustrations.

Illustration 1: Illustrations

Analogical Illustration



Schematic Illustration



DEVELOPMENT AND SCORING OF THE INSTRUMENTS

The four data-collection instruments developed for this experiment by the researcher included the interest questionnaire, the sentiment measure, Test I, and the interview guide. Test I was validated through pilot testing and through examination by a panel of experts which included professionals with seventh- or eighth-grade teaching experience and content specialists familiar with the topics of logic gates. The interest questionnaire was developed to collect information on possible covariates.

Test I

Test I was developed to measure the initial learning and retention of the materials presented during the learning task. The test items were classified as pertaining to either object attributes or relational predicates.

An example of an attribute test item, "Draw an AND gate and label its parts", was scored by awarding subjects 1 point for correctly identifying the inputs, 1 point for correctly identifying the output, and 1 point for drawing the correct symbol.

The following is an example of a relational predicate test item:

"Circle the correct output condition for an AND gate.

If input a is on and input b is on, the output will be ON OFF
If input a is off and input b is on, the output will be ON OFF
If input a is off and input b is off, the output will be ON OFF
If input a is on and input b is on, the output will be ON OFF"

It was scored by awarding the subjects 1 point for each correct answer.

A test score was tabulated for each of the respective test-item classifications. There was a total of 9 possible points in the attribute section and 16 possible points for the relational predicate section of Test I. Each subject had two scores each time the test was administered. The variable scores were assigned a number and brief descriptive title as follows:

1. Initial Attribute
2. Initial Relation
3. Attribute Retention
4. Relation Retention

Object Attribute Inter-rater Reliability

All variables collected using Test I were scored by the researcher. The relational predicate test items were not prone to subjectivity during scoring because of the dichotomous nature of the answers. Subjects were ask to indicate whether the output was "OFF" or "ON".

To ensure there was no subjectivity when scoring the object attribute test items, an independent professional rescored part of the tests. Forty test booklets, twenty from each group, were randomly selected. An instructor at the University of Maryland scored the object attribute test items. Once the variable was rescored, a pearson product moment correlation coefficient was computed in comparison of the researcher's scores with the independent raters scores. The correlation coefficient of .956 was significant at the .001 level.

In addition, the researcher compared differences in scores for each individual test score. The researcher and the independent scorer were within one point of each other ninety percent of the time and never more than two points apart on any one subject's score.

Sentiment Measure

A second instrument, the sentiment measure, was developed by the researcher to measure subjects' feelings towards learning the lesson they had just read. It was administered immediately following the treatment during the initial session. Scores were obtained using the following three items

1. I feel learning this lesson was:

very boring	boring	undecided	exciting	very exciting

2. I feel learning this lesson was:

very easy	easy	undecided	hard	very hard

3. Which of the following best describes how you feel about this lesson?

I hated it.	I did not like it.	undecided	I liked it	I liked it very much.

Each response was assigned a numerical value from 1 to 5 with the most negative response receiving a 1 and the most positive a 5. For example, in item one "very boring" was assigned a 1, "boring" a 2, "undecided" a 3, "exciting" a 4, and "very exciting" a 5. In item two "very hard" was assigned a 1, with "hard" received a 2, "undecided" a 3, "easy" a 4, and "very easy" a 5.

The variable scores collected on each of these items were assigned a number and brief descriptive title as follows:

5. Exciting/Boring
6. Easy/Hard
7. Like/Hate

Interview Guide

An interview guide was also developed by the researcher. It included a list of questions to help structure the interview process. The questions focused on the interest questionnaire and test items in an attempt to provide insight into why the subjects responded a particular way. The interviews were recorded using audio tape.

Interest Questionnaire

An interest questionnaire was developed in an attempt to identify possible covariates that may have influenced the results. This questionnaire was given prior to the learning task. The two variables derived from the questionnaire were identified by a number and brief descriptive title as follows:

8. Experience
9. Attitude

Variable 8 was derived by summing scores appointed to the responses on the first four items of the interest questionnaire. These items solicited responses indicating previous experiences that may have affected subject performance. For example, question one asked: How often have you tried to fix something electrical? The possible responses were either:

never once or twice not often but more than twice many times

These items were scored by assigning a numerical value of 1 to "never", 2 to "once or twice", 3 to "not often.but more than twice", and 4 to "many times". As stated previously, the scores for the first four items were summed to give each subject an experience score.

Variable 9 was derived by summing scores appointed to the responses on the last eight items of the interest questionnaire. These items solicited responses indicating incoming feelings that may have affected subject performance. For each item the subjects were asked to respond to a statement by circling one of four responses: "SD" for strongly disagree, "D" for disagree, "A" for agree, and "SA" for strongly agree. Each response was assigned a numerical value from 1 to 4 with the most negative response receiving a 1 and the most positive a 4. For example when scoring responses to the statement: I think electronics is boring, "SD" was assigned a 4, "D" a 3, "A" a 2, and "SA" a 1. When scoring responses to the statement: I like electronics, "SD" was assigned a 1, "D" a 2, "A" a 3, and"SA" receiving a 4. As previously stated, the scores for the final eight items were summed to give each subject an attitude score.

CONCOMITANT VARIABLES

As mentioned previously, the interest questionnaire was developed in an attempt to identify possible covariates that may have influenced the results. In addition to collecting information on possible covariates using the interest questionnaire, Stanford 7-Plus Achievement Test data was provided by the guidance counselor and

principal. The students took the test in April of 1990 during their seventh-grade year. Although a variety of scores were provided in various areas, Total language was selected for analysis because it represented a combination of reading and language scores. Because this was an experiment trying to isolate possible effects of illustrations, and the main part of the treatment included a reading passage, it seemed necessary to control for any differences in subjects' reading or language abilities. This variable was identified as Variable 10, Total Language.

STATISITCAL PROCEDURES

Correlational Analysis

Pearson product moment correlation coefficients were computed in comparisons of each dependent variable with each of the possible concomitant variables. In addition, pearson product moment correlation coefficients were computed in comparisons of each of the possible concomitant variables with each of the other possible concomitant variables (See Table 1). This was done to identify important relationships between variables and led to the selection of variables to be controlled when performing the analysis of covariance required for the hypothesis testing. All correlation coefficients were tested at the .05 level of significance. Any probabilities found to be less than .05 were so noted in tables as a matter of possible interest for some readers.

Variable 10, total language, was retained for further analysis when performing ancovas for dependent variables 1,2 , 3, and 4.

Table 1

Correlation of Dependent Variables With Selected Possible Concomitants

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
V8	-.099	-.007	-.035	-.012	.266**	.317***	.200*	1.00		
V9	.037	.004	.204*	.097	.427***	.307***	.418***	.658***	1.00	
V10	.294***	.361***	.368***	.209*	-.076	.066	-.031	.084	.088	1.00

*p< .05 **p< .01 ***p< .001

The total language scores were significantly correlated to all four variables. In addition, variable 9 was found to be significantly correlated to variable 3 and thus was retained in addition to variable 10 for further analysis when performing an ancova on variable 3. Variables 5, 6, and 7 were obtained using the sentiment measure administered immediately following the treatment during the initial session. Variable 9, which was a sum of items on the interest questionnaire that related to subjects' feelings towards electronics was significantly correlated with variable 5 and 7 and thus was retained for further analysis in an ancova for the two variables.

Variable 8, which was a sum of items on the interest questionnaire which related to subjects' experience working on or trying to figure out electronic things, was significantly correlated with variable 5. It was retained for further analysis in an ancova performed for variable 6.

Hypotheses Testing

Seven experimental hypotheses investigated in this study were tested at the .05 level of significance. Each hypothesis is listed in null form and is followed by results. Any probabilities found to be less than .05 were so noted in the tables. All raw score means and standard deviations are reported in appendix a.

HO1: There is no difference in the effect of the two types of illustrations on the initial learning of object attributes as measured by the object attribute test items in Test I administered immediately following the sentiment measure.

Analysis of covariance was computed using variable 1, initial attribute, as the dependent variable while controlling for total language. The analysis of covariance (Table 2) revealed an adjusted mean square ratio of 11.776 which was statistically significant ($p<.001$). Therefore, the hypothesis was rejected.

Table 2

Analysis of Covariance for Variable 1 Controlling for Total Language

Source	Sum of Squares	D F	Mean Squares	F-Ratio
Treatment	.586	1	.586	11.776***
Total Language	.664	1	.664	13.359***
Error	6.714	135	.050	

***$p<.001$.

HO2: There is no difference in the effect of the two types of illustrations on the initial learning of relational predicates as measured by the relational predicate test items in Test I administered immediately following the sentiment measure.

Analysis of covariance was computed using variable 2, initial relation, as the dependent variable while controlling for total language. The summary table appears in Table 3.

Table 3

Analysis of Covariance for Variable 2 Controlling for Total Language

Source	Sum of Squares	D F	Mean Squares	F-Ratio
Treatment	.129	1	.129	3.989*
Total Language	.595	1	.595	18.415***
Error	4.364	135	.032	

*$p<.05$. ***$p<.001$.

The analysis of covariance revealed an adjusted mean square ratio of 3.989 which was statistically significant the .05 level. Therefore, the null hypothesis was rejected.

HO 3: There is no difference in the effect of the two types of illustrations on the retention of object attributes as measured by the object attribute test items in Test I administered two weeks following the Learning Task.

Analysis of covariance was computed using variable 3, attribute retention, as the dependent variable while controlling for total language and attitude. The analysis of covariance (Table 4) revealed an adjusted mean square ratio of 10.077 which was statistically significant ($p<.01$). Therefore, the null hypothesis was rejected.

Table 4

Analysis of Covariance for Variable 3 Controlling for Total Language and Attitude

Source	Sum of Squares	D F	Mean Squares	F-Ratio
Treatment	.819	1	.819	10.077**
Total Language	1.582	1	1.582	19.481***
Attitude	.470	1	.470	5.875*
Error	9.260	114	.081	

*$p<.05$. **$p<.01$. ***$p<.001$.

HO 4: There is no difference in the effect of the two types of illustrations on the retention of relational predicates as measured by the relational predicate test items in Test I administered two weeks following the Learning Task.

Analysis of covariance was computed using variable 4, relation retention, and controlling for total language. The summary table for the analysis of covariance appears in Table 5.

Table 5

Analysis of Covariance for Variable 4 Controlling for Total Language

Source	Sum of Squares	D F	Mean Squares	F-Ratio
Treatment	.092	1	.092	2.128
Total Language	.212	1	.212	4.876
Error	5.128	118	.043	

The analysis of covariance revealed an adjusted mean square ratio of 2.128 which was not statistically significant. Therefore, the null hypothesis was tenable.

HO 5: There is no difference in the effect of the two types of illustrations on the feelings toward learning as measured by question 1 of the sentiment measure administered immediately following the Learning Task.

Table 6

Analysis of Covariance for Variable 5 Controlling for Attitude

Source	Sum of Squares	D F	Mean Squares	F-Ratio
Treatment	.089	1	.089	.115
Attitude	23.107	1	23.017	29.838
Error	112.623	146	.771	

Analysis of covariance was computed using variable 5, Exciting/Boring, as the dependent variable and controlling for variable 9, Attitude. The summary table for the analysis of

covariance is listed in Table 6. It revealed an adjusted mean square ratio of .115 which was not statistically significant. Therefore, the null hypothesis was tenable.

Hypothesis 6: There is no difference in the effect of the two types of illustrations on the feelings toward learning as measured by question 2 of the sentiment measure administered immediately following the Learning Task.

Analysis of covariance was computed using variable 6, Easy/Hard, as the dependent variable and controlling for variable 8, experience. The summary table for the analysis of covariance is listed in Table 7. It revealed an adjusted mean square ratio of .657, which was not statistically significant. Therefore, the null hypothesis was tenable.

Table 7

Analysis of Covariance for Variable 6 Controlling for Experience

Source	Sum of Squares	D F	Mean Squares	F-Ratio
Treatment	.411	1	.411	.657
Experience	9.239	1	9.239	14.777
Error	93.156	149	.625	

HO 7: There is no difference in the effect of the two types of illustrations on the feelings toward learning as measured by question 3 of the sentiment measure administered immediately following the reading of the Learning Task.

Analysis of covariance was computed using variable 7, Like/Hate, as the dependent variable while controlling for variable 9,

attitude. The summary table for the analysis of covariance is listed in Table 8. It revealed an adjusted mean square ratio of .593, which was not statistically significant. Therefore, the null hypothesis was tenable.

Table 8

Analysis of Covariance for Variable 7 Controlling for Attitude

Source	Sum of Squares	D F	Mean Squares	F-Ratio
Treatment	.457	1	.457	.593
Experience	20.997	1	20.997	27.252
Error	110.948	144	.770	

RESULTS AND DISCUSSION

Statistically significant differences were found in subjects' mean score on object attribute test items both during the initial administration of Test I and two weeks later when measured for retention. Therefore, when observing the mean scores, it appeared that those students who received the schematic illustrations performed better (81.2%) on the object attribute test items than their counterpart students (68.9%) who received the analogous illustrations. It also appeared that while both groups of students forgot part of what they had learned, the students who received the schematic illustrations performed significantly better two weeks later when tested for retention (60.6% to 45.1%).

These findings are probably not surprising to instructors who commonly use schematics, such as those in the electronics field. The basic nature of schematics would lead one to expect them to be

effective at presenting simple object attributes. Granted, the schematic does not look like the object it represents, but attributes can be represented by simple line representations.

Significant differences were found between subjects' scores on relational predicate test items during the initial administration of Test I, but two weeks later a retention test found no significant differences. Students who received the analogous illustrations had a mean score (81.7%) that was significantly higher than the mean score of those who received the schematic illustrations (74.6%), but their retention mean was not significantly higher (69.3% to 65.2%).

Analogous illustrations were expected to be effective for teaching relational types of information. Gentner's (1983) Structure Mapping Theory supports the idea that analogies help build bridges between what one already knows and what is being learned by representing relational types of similarities. The puzzling result is the lack of an affect when measured for retention. According to other studies (Hayes and Henk, 1983; Hayes and Henk, 1986), analogies tend to promote better retention. In this case while subjects who received the text with the analogous illustration performed better on the relational test items during the initial testing, no significant differences were found when measuring for retention.

There was no significant difference in any of the scores recorded from the questions asked on the sentiment measure. The different illustrations did not seem to have an effect on how well the

students liked or hated the lesson, whether they thought it was boring or exciting, or how easy or hard they thought it was.

Interviews

The previous findings should be taken in light of information collected during subject interviews. Following the initial session, 10 subjects, five from each group were randomly selected for interviews. The interview guide, which was used to help structure the process included questions that focused on the interest questionnaire and test items. The interviews were recorded using audio tape.

The interviews provided insight into the results that could not be dismissed. One of the first questions sought information regarding the subjects' perceptions of the term electronics. In most cases the subjects equated electronics with objects that use electricity. This was important when drawing conclusions about the interest questionnaire because many of the questions included the term electronics. When asked about feelings toward electronics, their answers reflected feelings towards appliances such as VCRs, stereos, and computers, not the components that compose them. This was important when considering that variable 8, experience and 9, attitude were derived from the interest questionnaire and were controlled for statistically when testing some of the hypotheses.

The interviews also revealed that while the analogous illustrations helped some students initially learn the relationships between their inputs and output, others were confused as to what a

logic gate was. This was reflected by one response to the question: "What is a logic gate?" " I have no idea" was one answer.

Some subjects interpreted the analogous illustrations as being logic gates. When asked "If I were to ask you to go to a store and buy a logic gate, would it look like this (pointing to the analogous illustration)?" one answered "yes".

Others realized the analogous illustrations were used to represent how a logic gate worked. For example when asked: "Why did I use a picture like this (pointed to an analogous illustration)?, one response was, "It is easy to understand because everyone uses a faucet."

When using analogies, a teacher usually interacts with students during the lesson pointing out important similarities and differences. When using analogous illustration with text, it is also important to point out similarities and differences between the target and the base domains. While use of either of these methods would have helped to eliminate confusion, it might have tainted the experiment. Both passages had to be free of specific references to the different types of illustrations.

Implications for Further Research

The use of a reading assignment supplemented with illustrations as the sole teaching method is not a typical procedure in most classrooms. Future studies may attempt to investigate the effectiveness of supplementing prose with other types of illustrations or presentations. For example, truth tables are commonly used when

teaching about logic gates. Future studies may wish to investigate the effectiveness of using different combinations of types of illustrations or diagrams such as truth tables with analogous illustrations or schematics.

It has come to the researchers attention that individual students' abilities to understand analogies may differ. In the future, it may be beneficial to measure this ability as part an experiment. Students ability to make inferences may definitely affect their ability to learn using analogous illustrations.

The lack of an effect for students who received the analogous illustrations on the relational predicate test items during the retention test is puzzling. This warrants further research.

As stated by Levie (1987), the picture research literature is like a group of small topical islands with few connecting bridges. This area is wide open for further research.

Significance of the Study

The findings of this study support existing theory on analogies and illustrations. In this study analogous illustrations were used to represent relational types of similarities to learn relational information. This was done by building bridges between what subjects already knew and what was being learned. The findings support both the Structure Mapping Theory and "systematicity principle" proposed by Gentner (1983).

This study also has implications for teachers and textbook writers. Textbook writers should consider the findings when

determining types of illustrations to use in text books. If the purpose of the illustration is to teach about relationships, an analogous illustration may be more appropriate than a schematic. Teachers may also use the findings when determining the types of illustrations they want to use to supplement information in their daily lessons.

In both cases precautions should be used when using analogous materials. It is imperative that subjects be familiar with the base domain. Duit (1990) discussed the use of analogies in textbooks and the use of analogies by teachers in a chapter on the role of analogies, similes, and metaphors in learning science. He reported that the "research available so far in this field revealed major limitations of analogy use in textbooks as well as in classroom practice" (p. 31). He also concluded that instructors often assume students understand analogies when in fact students are not familiar with the base domain or have limiting misconceptions about the domain.

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Appendix A: Means and Standard Deviations

Means and Std Dev. for all Dependent Variables

Raw Scores on Initial Test

		Initial Attribute	Initial Relations
Analogy	Means	6.197	13.053
	SD	2.104	2.628
Schematic	Means	7.303	11.908
	SD	2.040	3.484

Raw Scores on Retention Test

		Attribute Retention	Relations Retention
Analogy	Means	4.060	11.075
	SD	2.779	3.188
Schematic	Means	5.448	10.418
	SD	2.803	3.598

Feelings

		Exciting/Boring	Easy/Hard	Like/Hate
Analogy	Means	3.013	4.211	3.324
	SD	.959	.754	.893
Schematic	Means	2.961	4.092	3.227
	SD	.958	.897	1.008